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A Study of a Disease of the Bones and Joints of Swine

An Osteo-Arthropathy

H. C. H. Kernkamp
Division of Veterinary Medicine

UNIVERSITY FARM, ST. PAUL

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A STUDY OF A DISEASE OF THE BONES AND JOINTS OF SWINE, AN OSTEO-ARTHROPATHY

By H. C. H. KERNKAMP

INTRODUCTION

A disease of swine characterized by certain paretic-like symptoms has attracted much attention in recent years. A disease of this nature, aside from "sow paralysis," was either infrequently observed or little discussed a few years ago. Such cases of paralysis were looked upon as "rheumatic conditions" in many instances. In others the paretic-like symptoms were regarded as the manisfestation of some kidney disturbance or the sequela of an injury. Rickets and "posterior paralysis" are terms often applied to a condition showing symptoms as described.

The material presented in this study includes the results of experimentation and research, together with observations made on specimens sent to the laboratory, also results of examinations made on a number of farms where the disease existed. Many farms were visited and several examinations made before any experimentation was started.

Before planning the experiment, the data obtained from a number of field investigations were analyzed. A study of the anamneses, clinical and necropsy findings in each case indicated that the disease was of nutritional or trophic origin.

A second analysis of the data showed that various combinations of foodstuffs constituted the swine rations on the several farms. (Refer to protocols for specific rations.) A summary showed that the following foodstuffs were used: cereals fed as whole grains, including corn, oats, and barley; mill feeds, including shorts, bran, red dog flour, ground oats, ground corn, ground barley, and mill sweepings; commercial concentrates, including oil meal and tankage; dairy products, including whole milk, skimmilk, and buttermilk (creamery run or semisolid). Alfalfa, red clover, rape, blue grass, and rye represented the green foods where pasture was used. That which was called pasture in some cases amounted to nothing more than an exercising pen, the ground being barren and devoid of vegetation—strict "dry lot" conditions. A plank-floored enclosure was the only out-of-doors pen available in one case. Kitchen slops were utilized in some cases and on one farm a commercial stock food was being fed.

Component parts of the various rations were next considered, i.e., proteins, fat, carbohydrates, minerals, and the accessory food factors or vitamins. A few of the rations could be criticized as lacking in

protein, and others because of the quality of the proteins. An abundance of carbohydrates was found where the nitrogenous substances were low. In no cases were diets deficient in carbohydrates. The antiscorbutic or water soluble vitamin (C) was noticeably missing in some of the rations. However, it is questionable as to just what significance this vitamin has in connection with avitaminoses in farm animals. All of the rations supplied some of the Vitamins A and B. All rations which did not provide green pasture as a part of the diet were also deficient in the antirachitic vitamin. Many severe cases of an osteo-arthritic disease were observed, however, on farms where all these elements were being supplied in abundance. (See Protocol 6.) A lack of calcium seemed to be the outstanding mineral deficiency in many cases. Yet there were typical cases of a bone and joint disease in swine which were receiving foodstuffs that are said to carry large quantities of calcium. (Compare Protocols 6 and 7.)

EXPERIMENTAL WORK

Experimental work was begun in March 1921 and continued to the latter part of 1923. The pigs used in these trials were purchased at the South St. Paul stockyards and were from 4 to 5 months of age. They were brought to University Farm, immunized against hog cholera by the serum-virus method and kept in a 21-day quarantine before placed in the experimental lots. During this period a ration of corn, oats, red dog flour, and tankage was fed. The pigs were fed just enough of these foodstuffs to keep them at about an even weight. All pigs were in good physical condition at the end of this period, as far as could be determined. Each pig was ear-tagged and placed in a lot or group just before the experiment. The lot or group was based on weight, size, breed, and sex of each pig, and, as far as possible, the lots were equally balanced.

EQUIPMENT

Throughout the experimental period, except for the time required for weighing, the pigs were kept in pens in a large shed or barn. Each pen covered an area of approximately 200 square feet. The pen partitions were made of wood. On the south wall of each pen was a 30x40 inch window. These were closed only in inclement weather. The floors were of cement, troweled, smooth, and drained to one end. Each pen contained two V-shaped wood troughs, one for water and the other for feed. The scale for weighing the pigs was in a separate building about 50 feet distant. Once every 10 days the pigs were driven to these scales and weighed as expeditiously as possible. They were removed from the pens at no other time. Separate bins were

constructed for each diet mixture. Separate feed pails and scoops were provided, one for each diet mixture. Feed scales and charts were convenient for the caretaker.

Diet mixtures were compounded in from 200 to 400 pound lots. The constituents of each lot were weighed separately then dumped together and mixed thoroly. The mixture was agitated again when about half had been fed. The pigs were fed twice a day, morning and evening. The amount of feed for each lot at each feeding was weighed and recorded. Oat straw bedding was kept in one half of each pen at all times.

DIETS (RATIONS), LOTS, AND RESULTS

Diet 1

The basal ration or Diet 1 was compounded according to the following formula:

Corn	99 parts
Sodium chloride	1 part

Obviously, this is a poor ration. That such a ration is deficient and unbalanced has been known for a long time, yet it is a fact that a great many farmers feed swine rations almost identical with it. Rations of similar character have been used by other investigators (1) who have concluded that unless corn is supplemented it is not a good diet for growing swine.

The principal deficiency of this diet is the lack of protein. Zein, the principal protein of corn, is not a complete protein, as it is deficient in some of the amino acids essential for maintenance and growth, notably lysin and tryptophan (2). The diet is also low in mineral matter, particularly in calcium. According to Henry and Morrison (3) there are only .2 of a pound of calcium to every 1000 pounds of shelled corn. On the other hand, the phosphorus content of corn is quite high—6.9 pounds per 1000. Yellow corn is a good source of Vitamins A and B, and yellow corn was used throughout these experiments.

Four different lots of pigs (I, V, VII, XI), comprising 24 in all were fed Diet 1. Lot I was under experiment from April until August, 1921; Lot V from August until the middle of December, 1921; Lot VII, from January to April, 1922; Lot XI, in the spring of 1923.

The 8 pigs in Lot I averaged 97.5 pounds at the beginning of the experiment. Six, or 75 per cent, developed a disease of the bones and joints. In two, 9769 and 9781, the disease became very severe and marked evidence of arthritis and loss of function, akinesia algera, appeared (Fig. 1). The first evidence of disease was observed in 9781, 35 days after the beginning of the trial. Its average daily rate of gain for the 35 days was .5 of a pound. Following the appearance of first symptoms, this pig began to lose weight and continued to do so

for the remainder of its life. The disease became so marked that after about the seventieth day it could not rise upon its feet.

The second pig to show symptoms was 9769. This was 40 days from the beginning of the feeding period. Up to the time of the first symptoms it was making an average daily gain of 1.25 pounds. It gained only 2 pounds in the next 10 days and from then it lost weight continually. The course of the disease paralleled that of Pig 9781.

In Pig 9762, which was gaining at a rate of only .24 pound per day, the first symptoms were noted on the forty-second day. The symptoms never amounted to more than a slight stiffness and a tendency toward a stilty gait. This pig did little more than maintain itself for the remainder of the experimental period. The three remaining pigs in this lot, in which symptoms appeared, did not show symptoms until after 60 days from the beginning of the trial. The disease progressed slowly, but before the end of the experiment they were very lame and sore. Throughout the trial they were gaining in weight at an average of one pound daily.

Two pigs in this lot never showed evidence of an osteo-arthropathy. One of them gained only 15 pounds in weight during the entire period, the other, 25 pounds. Only slight skeletal growth was observed in either of these pigs and in Pig 9762. Their hair coats were rough, harsh, and dry and a marginal area of skin about the eyes was very light in color and more or less scurfy.

The 5 pigs in Lot V at the beginning of the experiment weighed on an average of 83.3 pounds each. One was a Duroc-Jersey, one a Chester-White, and three were crossbred, Poland-Duroc. In this trial two, or 40 per cent, of the pigs developed characteristic symptoms. The first to show symptoms was Pig 9785. This was the fifty-fifth day. Up to this time .58 pound was its average daily gain and for the remainder of the period its weight remained about constant. This pig did not develop a marked case of the disease. Pig 9792, the second of the lot to show symptoms, gained 3 pounds the first ten days of the trial but then steadily lost weight. The stiffness and lameness which developed, involved only the left hind leg. They were first observed on the seventieth day.

Two of the pigs, 9786 and 9793, barely maintained themselves throughout the entire period, in this case 110 days. One of them at the end of the period weighed 2.5 pounds less than at the beginning, and the other gained only 13 pounds. The condition of these pigs was comparable to that of Pig 9762 of Lot I. The fifth pig of this lot did little better than the two preceding. It gained only 32.5 pounds and made slight skeletal growth. No clinical manifestations of disease were observed in any of these pigs.

Lot VII was the third group to receive the basal ration. The average weight of the seven pigs at the beginning of the trial was 72.6 pounds. They then all appeared well and healthy. Four of them were Poland-Chester-White crossbreds and three were grade Duroc-Jerseys. Between the forty-fifth and fifty-fifth day of the feeding period three of them sickened and died. An autopsy showed that the most marked lesions were those of broncho-pneumonia and hemorrhagic enteritis, with petechia on the laryngeal and bladder mucosa. Clinically they had shown marked prostration and weakness with high temperatures. It was felt that the principal factor operating in connection with these casualties was a hog cholera "break." The remaining pigs were given large doses of anti-hog cholera serum and no further losses occurred.

Of the four pigs left in the lot three developed symptoms of an osteo-arthropathy; on the forty-fifth day in one, on the forty-seventh day in another, and on the fifty-second day in the third. The disease in one case became severe; the other two were mild. None of the pigs increased much in weight or made appreciable skeletal growth. The fourth pig lost 20 pounds in the experimental period; no clinical symptoms were observed.

Five grade pigs averaging 79.5 pounds each comprised Lot XI, the fourth group to receive this ration. Two were Durocs, two Polands, and one was a Chester-White.

Three of these never showed signs of a bone and joint disease and for a period of 90 days, the duration of the trial, their average daily gain per pig was .56 of a pound. Their skeletal growth was proportionate.

Two pigs developed the disease. Pig 9889 became a marked case. The symptoms began with a lameness in the right thoracic limb. Later it was lame in all four legs. The progress of the disease was slow but in 40 days from the appearance of the first symptoms, it reached a point where total loss of locomotive function was evident. The first symptoms were observed on the thirtieth day. This pig increased in weight at a rate of .4 pound per day until the time when it could not get about the pen unassisted. The second pig of the lot to show symptoms was 9902. They were not observed until the seventy-second day. This case did not become severe. It gained 55 pounds in 90 days.

Diet 2

A second diet was formulated to compensate for the protein deficiency of the basal ration. For this purpose a commercial grade of casein was supplied. Casein (4) carries large amounts of tryptophan

and lysin, the two amino acids deficient in zein. The ingredients and amounts of each constituting this ration were:

Corn	94 parts
Casein	5 parts
Sodium chloride	1 part

This ration was fed to nineteen pigs divided among three lots, II, IX, XIII.

Seven Duroc-Jersey pigs of good quality, averaging 94.4 pounds per pig, made up Lot II. This group was being fed at the same time as Lot I. Four pigs in Lot II made exceptionally good gains in weight. In fact, all made good gains in weight and increased in skeletal growth. After 100 days, the length of time that the pigs were kept on the experiment, each weighed on an average 242.8 pounds.

Four, or 57 per cent of the pigs in this lot, showed that some pathological process was operative in the bones and joints of the legs. Pig 9779, the first to show symptoms, developed a lameness and stiffness forty-one days from the beginning of the experiment. This progressed slowly, and later it required considerable urging by the caretaker to make this animal regain its feet. When walking the joints of the front legs were held immobile and a marked lameness of the left hind leg was evident. To stand or to walk caused this pig much pain. Notwithstanding the progress of the disease, this pig gained at a rate of .86 pound daily. The second pig in this lot to show symptoms was 9756. They were first noticed on the fifty-sixth day, and were particularly those of a shoulder lameness involving the right thoracic leg. This persisted throughout the trial.

Pigs 9764 and 9770 did not show definite clinical manifestations until the eighty-second and ninety-second days, respectively. These two pigs and the three others which never showed evidence of disease, made average daily gains of 1.6 pounds.

A point worthy of notice is that for the last 50 to 60 days of the feeding period all the pigs in this lot were more or less slow and sluggish in their movements. They were not excitable; on the contrary, they possessed a low temperament and were quiet and docile. Considerable urging and driving was necessary when taking them to or from the scales to be weighed. Their bodies were plump and smooth and their hair was sleek.

Lot IX, the second group to receive this ration, consisted of seven pigs. Results in this group were not the same as in Lot II. First, none of these pigs developed an arthritic or osseous disease. Second, as a group, their increase in skeletal growth and body weight was far below those of Lot II. In fact, they did not do as well as the groups fed Diet 1. This lot was being fed and cared for at the same time as

Lot VII, and a hog cholera break, as described for Lot VII, occurred in this group. Three pigs died; two others were very sick but later recovered. The remaining two were sick about one week and then recovered, and came back on full feed, continuing to gain at a rate of .5 pound per day. The two that recovered after being sick for a longer time weighed less at the end of the trial than at the beginning. It is quite probable that the complicating illness was responsible for the poor results obtained with this group.

Diet 2 was used a third time on a group of five pigs, Lot XIII. They averaged 83.5 pounds per pig when placed on experiment. Four of them were Duroc-Jerseys and one a Chester-White. All the pigs in this lot showed characteristic clinical manifestations of a bone and joint disease.

The first symptoms were observed in Pig 9907 on the fortieth day. Almost simultaneously with the onset of the symptoms the growth stopped and loss in body weight began and continued throughout the remainder of the period. The disease progressed and became so severe that by the eightieth day the pig could not stand up on its feet. The second to show symptoms was 9897. They were first noticed on the forty-sixth day. Up to this time the pig was gaining at a rate of 1.5 pounds per day, but like 9907, growth stopped and loss in weight began with the development of clinical symptoms. The disease progressed and by the end of 100 days the pig could not walk.

The next to show symptoms was 9905. They appeared on the sixty-fourth day and continued throughout the period. The disease, however, did not become severe in this case. The pig gained in weight at an average of 1.3 pounds per day up until the time of first symptoms. After this it lost weight continually.

The two remaining pigs showed a stiffened and stilty gait the last 30 days of the experiment. When they were standing the metacarpi were inclined downward and backward so that the front feet were placed farther under the body. These pigs gained in weight at approximately 1.8 pounds per day for the first 40 days. The following 30 days, or until the time the symptoms were noted, the rate of gain dropped to only .27 pound per day. They continued to gain at about this rate until they were taken off the experiment. Only a mild form of the disease was apparent in these pigs.

DIET 3

It seemed advisable to keep one lot of pigs on a diet carrying a liberal supply of the antiscorbutic vitamin (Vitamin C). For this reason the following ration was prepared:

Corn	99 parts
Sodium chloride	1 part
Cabbage, per pig per day	1 pound

The white parts of cabbage were used because they contain an abundance of Vitamin C, and because the food could readily be obtained only sound heads of cabbage were used. They were chopped into small pieces and placed in the feed trough once each day, about three hours after the morning feeding of corn. One pound of the chopped cabbage per pig a day was more than the pigs would consume at all times.

This ration was fed to one group of pigs, consisting of seven Duroc-Jersey pigs weighing on an average 89.5 pounds per head. This group was designated Lot IV and was carried along with Lots I and II.

The first pig to show symptoms was 9765. These were observed on the twenty-fifth day. For the first two weighing periods, the average daily rate of gain for this pig was 1.25 pounds, but at the next weighing, 10 days later, the rate fell to .5 pound, and the pig continued to lose weight from then on. The progress of the disease was rapid, in 15 days from the first symptoms total loss of locomotive function had occurred. Each time the pig would try to move about, loud squeals were emitted, indicating much pain.

On the fifty-first day Pig 9780 was stiff and lame for the first time. Prior to this it had increased in weight 50 pounds. It gained only 10 pounds for the remainder of the period, 47 days. This pig became very stiff, lame, and sore in the two front and left hind legs. However, this case did not become as severe as the preceding one.

The other pig in this group to develop the disease was 9757. It was 60 days before the first symptoms were observed. The disease was not as marked as in 9780. The rate of growth and increase in skeletal structures did not appear to be influenced by the disease, since the rate remained the same after disease was evident as before.

The four remaining pigs of this lot showed no indications of disease. Three of them made average daily gains of approximately .75 pound and the fourth of .25 pound. The skins and hair coats were similar to those of Pig 9762 of Lot I, Diet 1.

Diet 4

Diet 4, containing an additional amount of calcium, was made up of:

Corn	97 parts
Calcium carbonate	2 parts
Sodium chloride	1 part

This ration made available approximately 380 grams of calcium in each 100 pounds of feed. There was almost 22 times as much calcium in Diet 4 as in Diets 1, 2, and 3. These figures do not take into account the amount of calcium consumed in drinking water. An analysis of the water at University Farm made by the division of agricultural biochemistry, showed that it contained 164.5 parts of calcium carbonate per million. No records were kept of the exact amounts of water the

pigs drank but estimates based on relative amounts show that each pig received about .1 gram of calcium per day in water. This applies to all pigs in all lots.

Three lots of pigs received Diet 4. Seven grade Duroc-Jersey pigs averaging 94.6 pounds per pig at the beginning of the trial comprised Lot III. They were on experiment at the same time as Lots I, II, and IV. None of these pigs developed symptoms characteristic of the arthritic and osseous disease observed in pigs receiving the other three rations. Five pigs in the lot made good skeletal growth and increases in body weight. They gained on an average 1.09 pounds daily for 100 days. One gained at a rate of 1.48 pounds per day. This was very close to some of the pigs which received the protein supplement. Two pigs in the lot made little skeletal growth and increase in weight, their average daily gain being .31 pound.

An apparent interesting fact was that the pigs in this group always showed a lively temperament. When a person walked among them in the pen and when driven to the scales, they would frisk, run, and chase about, emitting loud squeals and grunts. This was not characteristic of the pigs kept on the other diets mentioned. Furthermore, these pigs would stop and root and devour sand and gravel unless forced to move. This was not characteristic of those receiving Diet 4.

The second time this ration was used was on Lot VI in the fall of 1921. This time five pigs of mixed breeding and averaging 80.8 pounds each were under test. None in this lot developed any indications of the disease. All of them steadily increased in weight from the beginning to the end of the trial, 110 days. Three made an average gain of 107 pounds; one gained 76 pounds; and the other, only 33 pounds. In temperament and disposition these pigs were similar to those in Lot III.

The results obtained with Lot VIII, the third group to receive Diet 4, were not so satisfactory from the standpoint of growth and increase in weight as those in the two previous trials. This group was being fed and cared for at the same time as Lots VII and IX and suffered a cholera "break" also. Five pigs in this lot sickened and died. An examination of the growth curves showed that two of the pigs, 9816 and 9826, only maintained themselves for the 100-day period. Three others made slight increases. There was no evidence of an osteo-arthropathy in any of the pigs that finished the trial.

DIET 5

Corn	92 parts
Casein	5 parts
Calcium carbonate	2 parts
Sodium chloride	1 part

This ration combines the supplements of Diets 2 and 4. Corn is the only ingredient carried at a lower level, the others are carried at the same level as when used to supplement the basal ration in their respective diets. Altho a small amount of calcium would be lost in decreasing the amount of corn, it would be compensated for by the amount of calcium combined in the casein.

Lot X, which consisted of five Duroc-Jerseys and a crossbred Poland-China and Chester-White, was fed this ration. The average weight of the six pigs at the beginning of the trial was 110.9 pounds. Hog cholera caused the death of two pigs in this lot. For the first 40 days before their sickness, five were gaining at a rate of .87 pound per day. The sixth pig began to make fair gains but this soon ceased and by the end of the experimental period it had increased only 15 pounds in weight. Two of the pigs maintained an even weight subsequent to the cholera "break." Another lost 15 pounds. None of the pigs in this lot ever showed clinical manifestations of lameness, stiffness, or other symptoms characteristic of the disease.

SUMMARIZED RESULTS OF FEEDING TRIALS

Briefly summarizing the preceding data, it is found that there were 75 swine used in the experiment. Two thirds of them received diets which were more or less deficient in calcium. Of this group 50 per cent developed symptoms of an osteo-arthropathy.

Thirteen of the 24 pigs fed the basal ration showed symptoms of disease. In one, appreciable clinical manifestations were first noted on the thirtieth day. This case marked the shortest time between the beginning of the trial and the appearance of the first symptoms. In another the first symptoms were noted on the thirty-fifth day. Four pigs showed first symptoms between the forty-first and forty-eighth days; two, between the fifty-first and fifty-sixth days; two, between the sixtieth and sixty-ninth days; two, on the seventieth day; and one, on the seventy-second day.

Some of the best average daily gains made by pigs on the basal ration, were made by three in which the disease developed. The rate of gain in five pigs was about the same after the appearance of symptoms as before. The average rate of gain in those pigs was between .25 and .5 pound daily. After the onset of the disease in two pigs, their weight remained nearly constant until the end of the trial. A steady loss in body weight occurred in three pigs after the appearance of first symptoms.

Forty-seven per cent of the swine receiving the protein supplemented ration, Diet 2, showed evidence of a bone and joint disease. The first symptoms were observed in one on the fortieth day, in two on the

fiftieth day, and in four on the seventieth day. In the greater number the symptoms appeared between the sixty-first and seventieth days. It was not until the eighty-sixth day that lameness and stiffness were noted in one of the group and in another it was not until the ninety-second day. Three, in which the disease was apparent, rapidly lost in weight from the appearance of the symptoms. The other pigs continued to increase in weight in spite of the disease. Aside from the pigs in Lot IX which suffered a setback from hog cholera, all but one started off at the beginning of the period by making splendid growth and weight increases.

An osteo-arthropathy developed in three, or 42 per cent, of the pigs receiving Diet 3. The earliest case and one of the most severe cases, occurred in this lot. The first symptoms were observed on the twenty-fifth day. The second and third cases developed on the fifty-sixth and sixtieth days. This was more than twice the time for the first.

None of the pigs receiving rations to which calcium carbonate was added at the rate of 2 per cent, developed clinical manifestations of the disease. Twenty-five pigs, distributed among four lots and fed at four different times, received such diets (Diets 4 and 5).

Of the total number of pigs on trial, 45 were males (barrows) and 30 females. Twenty-five of this group developed the disease and of this number 13 were females and 12 males.

SYMPTOMS

The symptoms are principally confined to such as denote abnormalities of the extremities. They vary with the location and the degree of the pathologic process.

In many cases a slight lameness is the only clinical manifestation. In others the symptoms become very marked. Some of the cases become so severe that a complete loss of locomotion is evident (akenesia algera). Such represent the extremes. Many and various intermediate manifestations are encountered.

In the incipient stage of the disease, if one front leg is involved, the particular type of lameness is a supporting leg lameness. In some cases this will subside after moderate exercise. With the progress of the disease, the symptoms become more distinct. When both front legs are involved, a stiff, jerky, and stilty gait is recognized. It is not uncommon to see pigs tumble forward on their faces if made to move faster than a walk, if they are lame in either or both of the front legs. When standing, the front feet are placed farther under the body, causing a marked volar flexion at the carpus (Fig. 3). In others the slope of the pastern is nearly verticle, and the pig appears to be standing on the tips of its toes. In some cases a marked anterior extension of the

joint between the first and second phalanges occurs. Puffing or swelling in any of the more distal joints of the legs does not occur. No appreciable changes can be determined by palpation or manipulation of the articulation in the early stages of the disease. Such examinations apparently do not produce pain.

As the disease becomes more advanced the animals are very reluctant to stand. Instead, they will flex the knees and bear their body weight upon them. Many will move about by walking on their knees. Pigs in this condition exhibit much pain when moving from one place to another. Decubitis and necrosis at the pressure points become evident, especially in cases of long duration.

If but one of the pelvic limbs is involved, a combined swinging and supporting leg lameness is usually observed. The affected leg is not carried as far forward as in a normal gait and the feet are quickly placed on the ground. Lameness of one hind leg only is not of frequent occurrence, in cases of long standing. On the other hand, a unilateral stiffness or lameness is usually the first clinical symptom. As a rule both hind legs become involved sooner or later.

When both hind legs are involved the gait is very distinct. The legs are held quite rigid and the stride is short and jerky. The lateral movements of the lumbar and sacral regions are minimized as much as possible because the animal tries to hold these parts rigid.

Pigs in more advanced stages of the disease try to place their hind feet as far forward as possible. This usually results in a "knuckling" or "breaking over" at the pastern joint, and lowers the posterior parts of the body. In some instances, flexion at the tarsus is so marked that the hind cannon slopes downward and forward at an angle of 45° and even more (Fig. 3). In many cases the posterior parts of the body are dropped so that the ischii and plantar surfaces of the pelvic limbs rest upon the ground. When moving from one place to another, the pigs prefer to drag themselves forward by using the front legs as a fulcrum. It is very difficult for a pig to regain its feet from such a position.

A recumbent posture is assumed at all times in those cases which can be classed as very severe. Many assume what may be called a "sidesaddle" position by resting the hind parts on the lateral surface of one thigh, the hind legs being extended to the opposite side. It is exceedingly difficult and often impossible to get a pig in this condition to stand upon its feet, even if manually assisted.

Periarticular thickening of the more proximal joints, shoulder and elbow joints of the front leg, stifle and hock joints of the hind leg, are not unusual findings. In many cases such enlargements may not be observed by visual inspection only, but can be detected by palpation. In a few cases a synovitis with effusion is observed. Thickening of

the skin at the pressure points and decubitis often results. Epiphyseal enlargements of long bones were not observed. Appreciable bowing or bending of the bones of the legs was not observed.

It is not uncommon to find fractured long bones or ribs in one or more pigs among a drove where this disease exists. Of the bones of the legs, the femur was fractured most often, and of the ribs, the seventh, eighth, or ninth. Among the experimental animals which could be watched from day to day, lameness was the first symptom. The lameness was observed in either one, two, three, or four legs. In nearly 59 per cent of the cases the first indications of lameness and stiffness occurred in the posterior extremities. About 37 per cent showed first symptoms in the anterior extremities. A small number of cases, 2 per cent, were observed, in which the lameness involved all extremities on the appearance of first symptoms.

Muscular atrophy, especially of the shoulder and thigh, is not uncommon. In many instances this results from disuse, especially if the disease is progressing slowly. On the other hand, cases have been seen in which a marked muscular atrophy occurred soon after the appearance of first symptoms. Twitching of the muscles has been observed in several cases. In some cases a rigidity of the muscles was noted and in others a marked spasticity of the muscles occurred. Reflex sensibilities were not impaired.

Symptoms denoting gastrointestinal and systemic disturbances are not pathognomonic. A partial anorexia usually occurs during the early stages of the disease and unless the diet is changed the pigs seldom return to "full feed."

Excessive rooting, digging, and the eating of earth has frequently been observed. (Specific examples are cited under Diet 4 and in Protocol 6.) This may be considered a sign or symptom. It indicates that the pigs are attempting to obtain something that is lacking in their dietary.

Mortality in this disease is often the result of starvation, because food and water are not so placed that severely affected animals can get it.

PATHOLOGY

The findings at necropsy are usually confined to the joints and bones. Joint and bone lesions of various kinds may occur. The particularly gross changes in some cases involve the osseous structures of the epiphyses of the long bones. Others show periosteal and subperiosteal hypertrophies. Ulceration, erosion, and atrophy of the articular cartilages are not infrequent findings. In many cases the synovial membranes and periarticular structures are the only structures involved. A combination of changes is, however, usually found.

The bones in which the pathological processes are most often observed are those of the limbs. Likewise, the ribs in nearly all cases shows certain abnormalities. At the autopsies of the experimental animals, the bones of the limbs particularly involved and given in the order of their frequency were: the humerus, femur, scapula, radius, tibia, and ulna. The mandible was involved in two cases. No definite changes were noted in the shins or feet, including all bones from the carpus or tarsus to the ground. The same is true of the vertebrae.

It is surprising to find that definite changes which can be noted by gross examination are not commensurate with the clinical manifestations. The converse of this is likewise true, altho it does not seem to occur as frequently.

More than a casual examination of a bone is usually necessary before even quite marked changes can be detected. In other words, to dissect the soft structures free from the bone will not in all cases reveal abnormal conditions. Appreciable gross enlargements of the ends of the bones have not been observed, or bending or curving of the shafts. As a matter of fact, measurements taken from X-ray plates showed that the proximal extremity of the humeri of pigs on low calcium diets, which had developed marked clinical symptoms of an osteo-arthropathy, were not as wide as those receiving the mineral supplement. Occasionally one finds cases in which the humerus, ulna, femur, tibia, fibula, or a rib is fractured or broken, or in which a swelling, callus, or retrogressive change may mark the site of a previous fracture.

Longitudinal sections of the limbs should be made in order to observe certain of the lesions. In extreme cases it is comparatively easy to saw through the bones. The spongy bone in these cases is very soft and its bony spicules in many cases can be crushed and broken with the thumb or finger. The marrow substance is usually white and is of a fatty consistency. In some cases the spongy marrow is very reddish in color, and in others it has a very mottled appearance. Hemorrhages toward the extremities of the shafts of the long bones are often seen. Hemorrhages into the epiphyses of the long bones are seen more often, and they usually are in juxtaposition to the metaphyseal cartilage. The proximal extremity of the humerus and the distal extremity of the femur are the two locations in which such changes are most frequent. Changes in the spongy substance of the short bones such as the carpals, tarsals, phalanges, and also the vertebrae, have not been noted particularly.

Periosteal and subperiosteal hypertrophies are not uncommon. In some cases these are very noticeable while in others they may pass unnoticed. Such hyperplasias can be seen best after the soft tissues are

removed and the bone sectioned longitudinally, or with the X-ray. Grossly this lesion appears as an accumulation of a grayish-white tissue which has a rather firm consistency. It can be cut quite easily with a knife and sometimes comes away in crumbly condition. It is not always distributed evenly over the surface of the bone, but may be deposited irregularly.

In three out of five X-ray plates made from severe cases of this disease, periosteal and subperiosteal thickening on the scapula was noted (Fig. 14). The thickened area was situated on the posterior border in two cases and on the anterior in one. A periosteal thickening on the humerus in three of the five cases and on the femur in a like number was also observed. There was no evidence of periosteal lesions on any of the other bones of the legs. In one of our cases, the periosteum was so thickened, that an area on the anterior surface of the femur was seven millimeters thick. In this case the hyperplastic tissue was situated on the outer side of the periosteum as well as beneath it (Fig. 10). A subperiosteal thickening on the posterior aspect of the neck of the humerus and just below the articular cartilage was observed in another case. Most often, however, the thickened periosteal lesion is situated at a point where it appears as an attempt to give additional support or where there is considerable muscle strain.

Only one or two articulations or joints may be affected. One may find changes of a certain form in one joint and a different kind in a second joint. Such findings may occur in the joints of the same leg or of other legs. The joints which showed gross changes most frequently were the shoulder (scapulo-humeral); hip (coxo-femoral); elbow (humero-radial); stifle (femoro-tibial); knee (ulnaro-carpal); and the hock (tibio-tarsal). The most striking changes were observed in the first four mentioned. No gross changes were noted in any of the more distal joints of the legs. In a few instances changes were seen in some of the intervertebral joints, especially in the posterior thoracic and lumbar regions. Enlargements of some of the costo-chondral junctions have been observed in a few cases.

Disarticulation is imperative if nutritional or deficiency disease is expected. In extreme cases well marked pathological changes will be found.

The articular cartilages in a number of cases showed striking abnormalities. In some they appear contracted and thrown into folds or wrinkles, causing deep linear sulci or furrows (Fig. 9). Such lesions when found nearly always involved those articular cartilages having marked convex surfaces. The wrinkling of the surface of the head of the humerus was usually well marked at the periphery. When this wrinkling was evident on condyloid articular surfaces, it was usually

in the grooves. At the bottom of the sulci the cartilage was atrophic and necrotic.

Erosive lesions were sometimes found. In some cases marked erosion of the articular cartilage had occurred. Areas of erosion measuring 1.5 centimeters in diameter and extending down to the underlying bone surfaces, were seen in a few instances (Figs. 7, 9). Such lesions occurred most often in the glenoid articular cavity of the scapula. No changes of this kind were found in the acetabulum. Erosions on the head of the humerus were not infrequent. In one case the proximal articular surface of the radius was involved. These areas were not septic. Culture media seeded with material from these areas remained sterile. The lesion is usually dry or nearly so because very scant amounts of synovia are present in such articulations. It was of interest to note that where even several eroded areas were present, there was no evidence of beginning bony ankylosis.

In less severe cases the articular cartilages may show slight depressions, causing an uneven and wavy surface, or the depression may be as little pits. Many cases have been seen where the cartilage is very thin and presents a deep purplish blue color. The cartilage in some instances is softer than normal—a state of chondromalacia.

In nearly all instances where extensive cartilage changes were found, there was also a marked periarticular thickening. The outer layer of the joint capsule is composed of dense connective tissue. It may be a centimeter or more in thickness. The inner or synovial layer may also be thickened. In some cases numerous long villous proliferations from the synovial layer have been observed. They are situated most often along the attached border of the capsule and instead of being diffusely scattered, they occur in more or less isolated clumps. They are often swollen and hemorrhagic. In other cases, however, they cover the entire synovial surface. The amount of synovial fluid is not commensurate with the hypertrophic serosa. Cultures made from these fluids remained sterile.

Lesions in the knee, hock, and the joints of the feet have never been as extensive as in the more proximal ones. As a matter of fact, no appreciable gross changes were noted in the joints of the feet. A thin, purplish-blue and slightly pitted joint surface constituted the most severe lesion in the knee. In only two cases the trochlear articular surface of the tibial tarsal bone showed a slight wavy, uneven, and roughened surface. A thickened joint capsule or periarticular thickening, especially at the knee, was seen more often.

Enlargements at the costochondral junction was observed in some cases. The enlargement in these cases was outstanding and could be recognized readily. The area was firm but could be cut quite easily with a knife.

A simple test which may be employed in an autopsy on a pig, which in a crude way offers an indication of the mineral status of the skeleton, is to force the blade of a knife into the articular surface of some of the long bones. The particular point to note is the degree of resistance encountered in forcing the blade into the bone. In hard bones it is difficult to engage the blade far beneath the articular cartilage, while in soft bones the blade will pass into the epiphysis quite easily. The proximal epiphyses of the humerus and femur and the distal epiphysis of the femur offer the best sites for the application of this test. A second test can be made in connection with the ribs. After the ribs are separated from the sternum, cut the intercostal muscles down to the vertebral column. This frees the rib. Next, grasp the rib firmly with the hands and break it at right angles. A normal rib will crack, splinter, and break through the soft structures. A rib from a mineral deficient pig will bend and break like a piece of cardboard.

Examinations of a great many of the intervertebral articulations, particularly those between the bodies of the vertebrae, have not revealed changes of sufficient importance to relate. On the other hand, deviations from the normal vertebral curves have been observed. The lumbo-dorsal curve was less convex, the lumbo-sacral more convex, and the sacro-coccygeal less convex than in normal swine.

The skin of many of the swine, especially on the ventral part of the abdomen and about the eyes, was thick, dry, and more or less wrinkled. The hair coat was coarse, dry, and lusterless. Decubital sores and especially callosities, were frequently observed. They usually occurred over the pressure points, i.e., knee, fetlock, pastern, and posterior surface of the hock. One usually observes a deformity of one or more of the legs. The thoracic leg may show marked volar flexion at the knee, fetlock, and pastern joints. In the pelvic leg there is anterior flexion at the hock joint, planter flexion at the fetlock and pastern joints. Contractions of the muscles and tendons of the legs often make it difficult and even impossible to extend or straighten the leg. Atrophy of the muscles, especially those of the legs, is not uncommon. Little or no subcutaneous or visceral fat was observed in any of the cases that had been down for from four to seven weeks. The teeth of the lower jaw in three of the cases were loose and the gums appeared very pale. The rami of the mandible in one case was very thick in the lateral diameter. In another, the bones around the nasal cavity appeared bulged. The tonsillar tissue of the soft palate in a few cases was intensely inflamed, and the crypts were filled with caseo-purulent material. In most cases this tissue was not involved.

Significant gross changes in the circulatory, respiratory, digestive, and genito-urinary systems were not observed. No gross changes were

noted in any of the nervous tissue. The spinal cords of many were examined but no changes noted. The spinal fluid was cultured in several cases, but in each case the media remained sterile.

HISTOPATHOLOGY

The subperiosteal thickenings are composed mostly of osteoid tissue. The trabeculae are usually wide and are not arranged in a definite manner. In one case where the periosteal lesion involved the shaft of the bone, the osteoid trabeculae were arranged at almost right angles to the vertical plane of the shaft. They were narrow and spaced about an equal distance apart and without much branching. Fine striations running lengthwise with the trabeculae can be seen in many cases.

Areas of osteoid of considerable thickness with small trabeculae radiating from it are often observed. Toward the centers of such areas a group or nest of osteoid cells may be situated. From 3 to 12 or 15 osteoid cells, some large and some small, compose such cell groupings or nests. Many small blood vessels enter the osteoid, especially where it is collected into wide masses. Collections of osteoblasts, 1 to 3 rows deep, were seen along the edges of the trabeculae in various places. It appears that a metaplasia of these cells into the production of osteoid occurs. The spaces between the trabeculae are often filled with fine connective tissue fibers, some osteoblasts, osteoclasts, leucocytes and erythrocytes, marrow cells and fat cells. The fibers are arranged in a dense reticulum. The inner layer of the periosteum in some cases showed a marked increase of fine white and delicate elastic fibers.

The epiphyseal cartilages were often affected. They were wider than normal and very irregular. The cartilage at the periphery of the bone is often wide and becomes much thinner toward the center. In some instances the cartilage spreads out at the periphery in a fan shape. The cells of the cartilage are arranged in columns separated by varying amounts of hyaline matrix. Some columns have two and three rows of cells, others have only one. The cells in the single row columns are usually smaller than those of multiple rows. The cells in the multiple row columns are packed closely together, whereas there is a considerable amount of hyaline matrix between those in the single row. The cartilage tissue along the upper border of the epiphyseal cartilage is usually a more adult type. This border is frequently very irregular. In some instances columns of cartilage cells extended through to its upper border. Many times one would find a very disorderly or hodgepodge arrangement of these cells at the upper border. Some of the columns would bend from a verticle to a horizontal plane. The cells in these columns appeared to be flattened or compressed. Quite fre-

quently small blood vessels could be seen entering the cartilage from the diaphysis and forcing their way between the columns.

There were cases in which the epiphyseal cartilage was much narrower. The columns of cartilage cells in these cases were not numerous. There was a greater amount of hyaline matrix between the columns and little or no proliferative activity was evident.

In a number of instances sections from the spongy bone of the epiphysis and diaphysis showed very thin and calcified spicules. The spaces between them were unusually large. In about an equal number of cases the trabeculae were composed of osteoid tissue. The disposition of the osteoid and its histology was comparable to that described above in connection with the periosteum. The vascular sinuses and blood vessels in many cases were packed with red cells. In most instances osteogenic cellular elements were present in great numbers.

ROENTGENOGRAPHY

Five cases with well marked clinical symptoms were studied with X-ray. The material for photographing by this method was obtained at necropsy. The legs were removed and the skin and most of the muscle carefully dissected away. The entire front leg was removed. The hind leg was disarticulated at the femoro-coxal joint. The pelvis was included with the lumbar, sacral, and coccygeal regions of the axial skeleton. In some instances the material was kept in a 3 per cent formalin solution before the X-ray plates were made. In others it was kept in an ice box.

There was marked evidence of calcium loss in the scapula in only one case. The others indicated only a partial loss. A very striking and outstanding lesion observed in three cases was that of a thickened periosteum. This occurred in the posterior border of the scapula in two cases and on the anterior in one. It was about .6 cm. thick at the widest point and sloped gradually at both ends (Fig. 14). Destruction and absorption of the articular cartilage was well marked in one case and partially in another. Marked calcium loss was not evident in these cases.

All five humeri showed evidence of calcium loss. Here again, one case showed a greater calcium loss than any of the others. It was not the same animal which had shown a greater loss in the scapula. Furthermore, the proximal end of the humerus appeared to suffer a greater calcium loss than the distal end. The proximal metaphyseal cartilage in four cases was completely calcified and appeared as a distinct white line in the X-ray plates. A complete calcification of the distal metaphyseal cartilage was seen in only one case. The distal articular cartilage in the humerus showed evidence of destruction and absorption.

In this case and in one other, a similar finding was observed in the proximal articular cartilage. In two cases rather wide and ill-defined trabeculae extended from the compact bone of the shaft into the marrow cavity which gave the impression that the compact bone was very wide. The compact bone in the case showing marked calcium loss was very thin. A thickened and calcified periosteum was observed in two cases.

The radius in two cases did not appear to suffer a calcium loss. The loss in one case seemed to compare with that of the humerus, while in the others it was less. No definite cartilage changes could be noted.

There appeared to be a greater loss of calcium from the ulna than from the radius in every instance. This is peculiar, because at autopsy the radius seemed to be affected more often than the ulna. A dark undulating line near the proximal end of the olecranon indicated that this cartilage had not become calcified. In four cases a similar line was noted at the distal end of the shaft.

No definite changes were observed in the carpals, metacarpals, or phalanges.

In four of the five cases it was clearly evident that a calcium deficiency existed in the femur. The compact bone of the shaft was very thin in two cases. In one of these a complete fraction at the distal end of the shaft was seen. The shaft in another case was thicker than usual and the posterior border was not concave. Wide trabeculae with rather ill-defined borders were observed. These extended from the compact bone of the shaft into the medullary cavity. The proximal metaphyseal cartilages were more completely calcified than the distal. No pathological changes of the articular cartilages could be determined. A slight thickening of the periosteum was noted in one case.

The tibia in only one case showed a marked calcium loss. The proximal metaphyseal cartilage in this case appeared to be completely calcified. The compact substance of the tibia appeared normal. No bowing or bending of these bones was observed. The distal metaphyseal cartilages in these cases were more completely calcified than the proximal. No definite changes in the articular cartilages could be noted.

The patella, fibula, tarsals, metatarsals, and the phalanges did not show changes.

A few plates were taken of the posterior portions of the axial skeleton. This included the regions of the lumbar, sacral, and coccygeal vertebrae together with the ossa coxorum. Nothing of particular significance could be learned from these plates.

Chart No. 1 expresses in a relative way the calcium status of the bones of normal and of calcium deficient swine. It represents a measure almost proportionate to the density of the bone, i.e., bones deficient in mineral matter are less opaque than those with a greater amount of mineral matter. The degrees of deficiency or calcium loss, i.e., slight, moderate, and severe, represent deviations from the normal. The normal in this case was obtained from the bones of two pigs which had been fed on balanced rations and were normal in so far as could be determined. The results of this tabulation, which represents only a few cases, bring out a point observed at autopsy and when examining the bones by sectioning and breaking. This is, that apparently a condition of halisteresis goes on in some bones more than in others of the same individual. For example in Pig 9800, the humerus shows a severe loss of calcium, the femur and ulna moderate loss, and in the scapula, radius, and tibia only slight loss. Pig 9801 shows severe loss in the scapula, femur, and tibia, with moderate loss in the humerus, ulna, and radius. Pig 9799 shows a slight loss in the ulna, a moderate loss in both scapula and humerus, and a normal condition of the radius, femur, and tibia.

CHART NO. 1

SHOWING CALCIUM LOSS AS PER X-RAY READINGS IN BONES OF SWINE

Pig	Lot	Diet	Bones					
			Scapula	Humerus	Radius	Ulna	Femur	Tibia
9799	VII	1	++	++	N	+	N	N
9801	VII	1	+++	++	++	++	+++	+++
9822	VII	1	+	++	N	N	++	+
9800	IX	2	+	+++	+	++	++	+
9804	IX	2	+	++	+	++	+++	++
9821	VIII	4	N	N	N	N	N	N
9843	VIII	4	N	N	N	N	N	N

NOTE.—N=normal; +=slight; ++=moderate; +++=severe.

PROTOCOLS

A few representative field cases are presented in the following protocols. They show the conditions under which this disease has been observed.

PROTOCOL 1—REDWOOD COUNTY

The owner had 4 Duroc-Jersey sows which he said were "down in the back." They were in very poor physical condition. At the time of our visit in November, and for several weeks prior they had been kept in a small orchard which had been seeded to bluegrass. Their diet consisted of a slop feed of ground oats, kitchen refuse, and water in the morning, and new corn in the evening. In addition, they could have what grass they could get. Each sow was nursing a litter of pigs. One was nursing 7 pigs, one, 4, and two, 5. The litters ranged from

6 to 8 weeks of age and the pigs were in good physical condition and very active. Three of the sows had developed the "down in the back" condition after farrowing and the fourth some time before farrowing.

The following symptoms were observed: temperatures and respirations normal; visible mucous membranes normal; feces and urine voided appeared normal; appetites good. The animals were recumbent and unable to get up on their feet unless manually assisted. When standing marked flexion at the hock and fetlock joint were observed. The posterior parts of the body were thus lowered. Marked flexion at the knee joint was also noted. It was painful for the sows to stand or walk, and the stride was stiff, short, and jerky. They were sensitive to pin pricks. No appreciable swellings, enlargements, or heat was noted over any of the palpable articulations. The sows had not moved a great distance from the places where they were lying. An area about 7 or 8 feet in diameter was rooted and dug up around them, representing the zone of their travels. No autopsies were obtained. There were no other swine on this farm.

PROTOCOL 2—KANDIYOHI COUNTY

Nine in a drove of 30 Duroc-Jersey pigs, between 75 and 125 pounds in weight, were showing typical symptoms of an osteo-arthropathy. They were from 5 to 6 months of age and in poor physical condition. They were housed in a dark, unsanitary and poorly ventilated shed but were fed out-of-doors. We visited this farm in March, 1918. Five of the 9 affected swine assumed a semi-sitting posture by extending the pelvic limbs obliquely outward and forward, resting on their thighs. They would propel themselves about with the thoracic limbs and drag the pelvic limbs. No effort was made to stand even if an animal were assisted. Two of the pigs exhibited a spastic paralysis of the hind legs. Atrophy of the extensor and flexor groups of muscles was noticeable. Deformities, such as marked flexion at the carpal and metacarpo-phalangeal articulations were observed in the remaining 4 pigs. Similar deformities at the tibio-tarsal and metatarso-phalangeal articulations were noted in 3. There were no appreciable swellings or enlargements at any of the joints. Examinations of the circulatory, respiratory, digestive, and genito-urinary systems were negative, as far as could be determined. The diet of the pigs consisted chiefly of ear corn, water, and a little skimmilk. A little barley or oats was fed occasionally. No autopsies were obtained. Inquiry revealed that some of the affected pigs had been in this condition for approximately two months. The owner said that he had seen pigs in the same general condition on his farm before, and that, as he remembered, none ever recovered.

PROTOCOL 3—WRIGHT COUNTY

In a drove of 47 swine, 29, or 61 per cent, showed evidence of a bone and joint disease. Almost complete loss of control of the hind legs was readily noted in 18. Most of the pigs assumed a sitting posture with the feet extended to one side. A few extended the hind legs directly backward so that the weight of the hind parts would rest on the dorsal surface of the pelvic limb from a point just below the stifle to the hoof. The hair on these surfaces was rubbed off yet no bruises or injuries of the skin could be observed. The pigs were sensitive to pin pricks. Muscular atrophy of the thigh and leg muscles was noted. No definite joint injury could be determined by clinical examination. Quite remarkable was the way in which these pigs would move about, using the forelegs to drag or pull themselves forward. Four of the affected pigs could not move from their places. These pigs could not stand up on their feet unless given manual assistance, and this caused much pain. The anterior members alone were involved in some cases. The pigs would move about by walking on their knees and fixing or immobilizing the shoulder joint. Some were very stiff and jerky in their movements. This drove of pigs was between 6 and 7 months of age. They averaged about 120 pounds in weight, and were of mixed breeding. The owner was very much discouraged. He had expected that by that time they would have been about 100 pounds heavier. The disease in some of the pigs had been in progress for as long as 3 months. Others were becoming affected from time to time. Their ration consisted of equal parts ground oats and barley made into a slop with water and fed in the morning. In the evening they received shelled yellow corn. The housing facilities were fair. They had the run of a wooded pasture but the foraging was poor at this time of the year, April. No deaths were reported and no autopsies obtained.

PROTOCOL 4—FREEBORN COUNTY

Eleven pigs on a farm all showed definite clinical symptoms of an osteo-arthropathy. They were Duroc-Jerseys, about 6 months of age and about 100 pounds in weight. The environment was conducive to a mineral deficiency disease. The house and pen in which the animals were kept had a solid plank floor. The pen was about 12 feet square and out-of-doors. No other runway and no pasture were available. Ground oats and barley were the principal feeds. Some nubbins of soft silage corn were thrown into the pen for a few days while the silo was being filled. The pigs could not walk. They would move about by using the front legs as a fulcrum, dragging the hind parts forward. Marked flexion at the joints was evident. Manipulations of the shoulder, elbow, stifle, and hock joints caused them much pain.

No appreciable enlargement of these joints was noted. A "wanting" expression of the face was clearly recognizable. No other symptoms were noted. Three weeks had passed since the owner had noticed the first signs of the disease. That the pigs were in great need of mineral matter was stressed. Bone meal and a teaspoonful of cod liver oil for each pig every day, were prescribed. The owner said that he had raised pigs in the same way and in the same place for thirty years and never before noticed such conditions. It was learned later that he did not follow the suggestions as to the use of bone meal and cod liver oil, but disposed of the pigs.

PROTOCOL 5—FREEBORN COUNTY

Five in a drove of 60 spring pigs showed characteristic symptoms of a bone and joint disease. The pigs had the run of a barn yard and an adjoining orchard. Their diet consisted of a slop feed of ground oats and barley mixed with skimmilk and of ear corn scattered on the ground. Four of them could get about fairly well, but the fifth could not. The first pig's symptoms had appeared about a month or five weeks previous. The owner said that because they could not "keep up" with the rest he separated them from the drove, allowing them the run of the farmstead. At the time of our visit these pigs were still running about the farmstead and did not show evidence of disease. A careful inspection disclosed the fact that near the farm house was a pile of old plaster and a mortar box. The owner said he had noticed the pigs eating this material. This indicated that lime was one of the elements lacking in their diet and it was suggested that he supply all the pigs with this material. At a later date it was learned that he had complied with this suggestion and that no new cases developed.

Eight other farms in the immediate vicinity were visited and from 15 to 65 per cent of the pigs were similarly affected. The local veterinarian knew of still other farms in the vicinity where this disease existed.

PROTOCOL 6—WASECA COUNTY

A disease of swine reported to be quite extensive in this section of the state, was investigated in August, 1922. The first drove visited consisted of 180 head of purebred Chester-Whites, between the ages of 4 months and 3 years. About 130 were farrowed in the spring of 1922. Sixty-nine showed evidence of an osteo-arthropathy. A good clinical picture of almost any stage or degree of the disease could be observed. The oldest cases had shown symptoms for less than a month and the pigs affected were between 5 and 6 months of age. Only three of this group were able to move about without much difficulty. A

number exhibited marked symptoms of lameness, the stride being short, stiff, and jerky. The lameness was apparent in one front leg in some cases; in both front legs in others. In some, one hind leg was involved; in others, both hind legs. Others were lame in both front legs and one hind leg, or both hind legs and one front, or in all four legs. Autopsies of two of the most severe cases revealed extensive arthritic and osseous changes. The joints particularly involved were the shoulder, elbow, and stifle joints. The articular cartilages were thin, uneven, and wavy or wrinkled, especially those of the head of the humerus and the condyles of the femur. The synovial membranes were thickened and villous-like proliferations extended into the cavity. Some periarticular thickening was apparent. The long bones, humerus, and femur would break very easily. The ribs would also bend and break easily. No gross changes were noted in any of the thoracic or abdominal viscera.

These pigs had been fed on ground oats and corn, shorts, and cooked barley, mixed into a slop with skimmilk or buttermilk. In addition they had access to alfalfa and rape pasture. The pasture was large enough and they had plenty of green forage. It was noted that throughout the pasture there were areas where the soil had been rooted or dug up by the pigs. As further proof of this the faces of the pigs were literally covered with dirt. The owner was contemplating "ringing" in order to prevent rooting. Houses, sheds, pens, troughs, and feeding floors were exceptionally well constructed and kept in good condition and clean.

A diagnosis of a calcium deficiency disease was made, and the owner was advised to supply calcium. Calcium carbonate in the form of air-slaked lime, dried and powdered, was added to the ration at the rate of 5 pounds to each 100 pounds of feed. A report received the following January said that shortly after the treatment was begun, all but three of the affected pigs made excellent recoveries and no new cases developed.

A next neighbor with 44 purebred Chester-Whites, 13 spring pigs, showed well marked clinical symptoms of the same disease. His swine were kept under practically the same conditions. The same treatment was advised and the results were just as satisfactory.

PROTOCOL 7—WASECA COUNTY

There were about 250 purebred Duroc-Jersey swine in this drove, of which nearly 200 were spring farrowed. There were no clinical cases of an osteo-arthropathy among any of the swine at the time of the visit and the owner said he never had had a hog which showed symptoms such as we described. Inquiry revealed that the diet of these swine consisted essentially of the same foodstuffs as those referred to in the preceding protocol, with the addition of ground bone.

The pigs ate considerable amounts of this material. An interesting and striking observation was that the pastures were not rooted or dug up by the pigs and none of the animals wore rings. A report from this farm the following January showed that no cases ever developed.

PROTOCOL 8—LINCOLN COUNTY

This drove of swine seen in May consisted of approximately 300 head of Poland-Chinas. Some were purebred, others grades. Thirty were winter farrowed (in November and December). Nearly 60 per cent of these showed symptoms of a bone and joint disease. The owner said some of them were "weak in the legs" before weaning. He attributed this to the unfavorable season for farrowing, saying that the sows were poor "milkers" and that the pigs were usually small when born. Seven yearling gilts also showed symptoms of stiffness and lameness. When forced to get up they would walk a short distance and lie down again. These gilts had all nursed litters earlier in the spring. The owner was feeding his entire herd of 300, a mixture of corn, oats, and barley, self-fed in three large hoppers and tankage from a separate hopper. A sufficient supply of water apparently was provided. No special provisions were made to take care of the crippled pigs. No autopsies were obtained. The owner was advised to supply a liberal amount of bone meal and keep it before the pigs at all times. Better pasture facilities were also suggested. This he agreed to. No further word was ever received from him.

PROTOCOL 9—DAKOTA COUNTY

Eighteen fall gilts with well marked cases of a mineral deficiency disease were found on this farm. Akinesia algera was evident in most of them and it involved all four legs. Some of the pigs were able to move about, but with much pain. The humeri in two pigs were fractured, and the tibia and fibula in a third. The fractures we believe were the result of rough handling on the part of the caretakers. A disease of this kind lends itself to such injuries quite readily. It was learned that most of these pigs had shown symptoms for as long as two months. None of those affected improved and none died. A post-mortem on two of the affected pigs revealed marked arthritic and osseous changes. The skin and hair coats were harsh, coarse, and rough. The body was emaciated. The muscles of the legs were atrophied, firm, and dark in color. There was a periarticular fibrous thickening about the shoulder joint. The synovial membrane was hemorrhagic and thickened, especially that part attached to the humerus. The articular cartilages were uneven and wrinkled, and some erosive changes were observed. The articular cartilage of the elbow joint was also wrinkled and very thin, especially over the contact parts. One

could force the knife into the ends of the long bones very easily, and the bones were easy to saw through. The frontal bones of one of the pigs seemed to be thicker than normal. No gross lesions were found in the thoracic or abdominal organs.

Besides the 18 affected pigs there were 52 pigs of approximately the same age. There was no evidence of disease in these pigs. All pigs on this place were purebred Hampshires. Their diet consisted mainly of soaked corn, oats, and barley, much of which had been scorched and burned in an elevator fire. A small amount of semi-solid buttermilk was also fed. Pasture was not available. Calcium carbonate was suggested as a mineral constituent which was to be supplied regularly. The suggestion was carried out and the owner later informed us that seven pigs made suitable recoveries or were at least marketable, and no new cases developed.

PROTOCOL 10—ROCK COUNTY

Eleven in a drove of 78 grade and crossbred swine were in such a crippled condition that it was almost impossible for them to move about. They were housed in a straw shed with a board floor and had the runway of a barnyard where a few thin milk cows and several horses were kept. Ground corn, red dog flour, oil meal, and a commercial stock food were mixed into a slop and fed to them in the morning. Yellow ear corn was scattered on the ground at the evening feeding. All affected pigs were born the previous October and were 6 months of age. The first signs of stiffness or lameness had been observed about 6 weeks before. As the owner put it, "first one, then another, then another, etc., developed the disease." The symptoms and post-mortem findings were similar to those already described. Disposal of the most severely affected pigs was advised, and bone meal and cod liver oil were prescribed for those to be kept. A report was received from this man about 4 months later expressing his satisfaction with the results obtained.

PROTOCOL 11—RAMSEY AND HENNEPIN COUNTIES

This protocol covers conditions found on a group of farms where the principal foodstuff of the swine consisted of garbage. Knowledge concerning the conditions on these farms was based on several years' acquaintance. On some of the places only about 50 head of swine are kept; on others as many as 500. As a general rule the swine are kept under "dry lot" conditions, pastures being available on only a few farms. The facilities for feeding and housing ranged from very good to very poor. Some feeders "finished off" their swine on cereal grains, others never fed anything but garbage. It is the practice on some of the places to purchase feeder pigs (pigs weighing from 60 to 110 pounds) and feed them out, while others raise their own. We have

never seen or heard of a disease characteristic of an osteo-arthropathy on any of these farms. This is not surprising when one considers the variety of foodstuffs represented in garbage. It should carry some of all of the elements necessary in nutrition.

DISCUSSION

In literature on hog-raising, one can find descriptions of and references to a disease in many respects similar to that described. The agreement of these reports has to do chiefly with the clinical manifestations or symptoms. The morbid anatomy, both gross and microscopic, tho not agreeing in all points, nevertheless shows that certain bone changes are more or less alike. The differences are mostly those which indicate osteoporotic changes as one extreme and rachitic changes as the other. However, an admixture of changes characterizing both osteoporosis and rickets are more often observed. The pathology of diseases of this nature is not specific. It is, however, receiving much study at the present time.

Rather close agreement is found as to etiology. We refer to the fact that the disease is one of trophic rather than of microbian origin. The specific nutritive elements concerned and their relation to one another as causative agencies, are matters upon which there are differences of opinion.

Goldberg, Maynard, Williams, and Christy (5) stress the importance of the addition of cod liver oil or alfalfa hay to the ration as factors favoring the prevention and cure of swine affected by "posterior paralysis." In one experiment their basal ration consisted of yellow hominy, 200 parts; standard wheat middlings, 100 parts; casein 4.5 parts, mixed into a slop with an equal weight of skimmilk, raw in some instances, pasteurized in others. Pigs fed this ration became stiff and lame. When the condition had progressed to a point which it was thought characterized the disease (posterior paralysis), some were destroyed for examination, others used to test a cure. One was cured by adding cod liver oil to the ration. A more interesting result was the fact that similar clinical and pathological changes were observed in pigs receiving as a supplement to the basal ration, a mineral mixture (equal parts of calcium carbonate and bone meal) equivalent to 2.5 per cent of the ration. Two of the affected pigs in this group were restored to health after adding alfalfa hay to the ration.

In another experiment a group of nine pigs was fed a ration composed of yellow hominy, cottonseed meal, middlings, molasses, calcium carbonate, and bone phosphorus. Within two months all were stiff. Four were killed and examined. They showed definite bone changes. The remaining pigs for five days received in addition to their regular

diet, 30 spoonfuls of tomato juice. After this period alfalfa hay at the rate of 5 per cent of the ration was fed. This line of treatment was not begun until all the pigs were in the very late stages of the disease. Within two months from the beginning of the treatment the pigs returned to normal condition. Minerals were fed *ad libitum* it is said, "but the pigs appeared to have made marked improvement before these minerals were consumed at all."

In a study of the factors responsible for rickets or partial paralysis in swine, Bohstedt, Bethke, Edgington, and Robinson (6) in Ohio, fed a large group of pigs, ground white corn, wheat flour middlings, linseed meal, blood meal, and salt as the basal ration. This was supplemented with minerals (calcium carbonate, disodium phosphate, and precipitated bone flour), protein (casein) and Vitamin A (cod liver oil, whole and aerated). These supplements were fed alone with the basal ration or in combination. The experiment included 10 lots of 8 pigs each, and continued for a period of 160 days.

Their report shows that 31¼ per cent of the pigs died. The experimenters say that death was "due to rickets, respiratory trouble, or the effects of deficient rations generally." In all but one case the deaths occurred in the lots not receiving additional vitamins. Lameness was not observed in any of the pigs which received cod liver oil. One case occurred in each lot receiving mineral or protein supplements. Three cases developed in the lot receiving only the basal ration.

The results of the experimental feeding trials at the Minnesota Station indicate that calcium is a very significant factor in connection with the etiology of the disease here reported.

Rations low in calcium but carrying a good supply of Vitamin A were fed to 50 head of swine. Of this number, 25, or 50 per cent, developed a clinical syndrome characteristic of a bone and joint disease. A difference in the degree of severity of the symptom complex was observed in the affected pigs. The earliest indication of disease occurred on the twenty-fifth day in one case. In another case the first symptoms were not noted until the ninety-second day. Symptoms in the other cases appeared between these two extremes.

When it is remembered that the average weight of the pigs at the beginning of the feeding trial was 87.22 pounds per head and that the age varied between 4 and 6 months, then 50 per cent of "takes" is a large number. It might reasonably be thought that if the pigs had been younger and less mature, a greater number of cases would have developed. Under field conditions, the disease was found to occur most often in pigs weighing between 60 and 125 pounds. More of the pigs weighed nearer the former figure than the latter. In some

instances pigs weighing about 30 pounds showed typical symptoms of the disease. Heavier swine were also affected.

Another significant fact pointing to the rôle calcium plays in relation to this disease, is that none of the pigs receiving calcium carbonate, equal to 2 per cent of the ration, developed an osteo-arthropathy. In all there were 25 pigs which received this supplement. In this connection attention is again called to Protocols 6 and 7. These offer a striking example, showing the results of the use of an additional mineral supplement in the dietary. Other similar cases could be cited.

Elliot, Crichton, and Orr (7) reporting upon some of their work in connection with "Rickets in Pigs" obtained results similar to those of the Minnesota Station. They fed various diets to several lots of swine. One of the rations was exceptionally low in inorganic matter but carried an abundance of the Vitamins A, B, and C. Within 60 days from the beginning of the trial the pigs showed marked evidence of malnutrition. They moved about with very stiff and stilty strides. Another group which received the same ration plus inorganic matter, consisting chiefly of calcium salts, did not show such symptoms. The pigs of this group grew and increased in weight at a rate which was 50 per cent better than those in the first lot.

A ration which was poor in both protein and minerals constituted the basal ration of the same experimenters in a second trial. One lot of four pigs received this ration. For a second lot protein only was supplemented. A mineral mixture plus the basal diet was fed to a third group, and a fourth group received both protein and mineral matter. The results were quite striking. No manifestation of disease (rickets) was observed in the pigs receiving the salt mixture as part of their diet. On the other hand rickets developed in those not receiving the salt mixture.

Reports of investigations of nutritional studies or feeding trials with swine, often contain sections or paragraphs describing certain clinical manifestations or disease. Stiffness of gait, lameness, or paralysis are the phenomena which particularly characterize the disease. Many of the reports contain nothing more than a record of such symptoms. Others describe in a little more detail certain factors in the disease. In this connection some of the early work of Hart, McCollum, and Fuller (8) is of interest. One of the rations they were feeding a group of swine, carried phosphorus at a very low level. In fact, it supplied only 1.12 grams of phosphorus per pig per day. It consisted of rice, wheat gluten, and bran, plus a mixture of sugar, sodium chloride, magnesium chloride, and potassium sulphate.

One pig receiving this diet showed the first signs of stiffness on the thirty-third day. The stiffness occurred in the hind legs and

resulted in partial loss of control. Within a few days the two other animals of the lot showed similar symptoms. The symptoms became more severe, and later the pigs were totally disabled and could not move about. The authors state that "when standing, the hind limbs assumed an oblique position, the hind feet resting far beneath the body and near the fore feet. One animal in this lot entirely lost the power of sustaining its hind quarters." Similar syndrome occurred in a second lot of pigs which were fed the same ration, but at a later date. A small outside pen (free from vegetation) was provided for the latter group. This afforded opportunity for exercise, a point which the authors thought might have been a factor in connection with the development of the stiffness.

Gross examinations of some of the long bones from these animals showed that they were of a looser texture than those from normal swine. They were more spongy and their breaking strengths were lessened. The writers note that the bones indicated severe osteoporosis. Bones from swine fed a ration carrying sufficient amounts of calcium phosphate did not show such characteristics. Neither did the latter show any of the clinical symptoms described.

Another very interesting example of a paretic-like disease of swine was observed in connection with certain feeding experiments at the experimental farms, Agassiz, Canada. A large number of pigs were fed rice meal to compare its feeding value with that of more standard condiments. Rice meal, skimmilk, and mangels constituted the basal ration in these trials. This was supplemented with wheat shorts, oats, barley, peas, ground alfalfa, potatoes, and dried blood, in various combinations. P. H. Moore (9) when reporting the results of these trials, emphasizes the fact that in every instance in which rice meal was fed as a part of the diet, the hair coats of the pigs became rough and that later, symptoms of stiffness and lameness were evident. The first signs of stiffness occurred as a rule about the fiftieth day. Two pigs, however, showed such symptoms at about the thirtieth day. None of the pigs receiving diets in which no rice meal was used ever showed signs of stiffness, lameness, or roughened hair coats.

Hadwen (10) reporting upon these pigs from the standpoint of a clinician and pathologist, notes that a painful lameness developing very suddenly and a wild staring expression of the face are characteristic symptoms. In reference to this he says: "A pig that had been quite active in the evening would be lame the following morning,"—with a "wild staring facial expression with the eyes nearly popping from the sockets." The character of the lameness or of the posture assumed when standing or walking is not described in detail. From the attitude assumed by affected pigs (deductions of the writer from

photographic plates), it would appear that the animals were endeavoring to fix the position of the legs when in a standing position and then allow the axial skeleton to decline backward and downward. The front feet are placed farther forward than normally as are also the posterior feet. The lowered sacrum results in a marked flexion at the hock and fetlock joints, and thus the long axis of the metatarsus approaches a horizontal more nearly than a vertical plane. Hadwen also speaks of heart attacks as a frequent symptom in many of the affected swine. These were characterized by heavy breathing for a short period followed by loss of breath, and a stiffening out as if the animals were going to die. Such attacks were of short duration. They occurred in some pigs as many as two or three times in a single day. Some of the affected pigs were killed. A post-mortem showed no changes in any of the viscera. The bones were very soft and could be cut easily with a knife. No further descriptions were included. Since an osteogenic weakness was the particular manifestation and since it was known that rice meal is deficient in phosphorus, the idea was put forth that therein was a possible explanation for the disease. The idea that rice meal contained substances of a toxic nature was largely abandoned.

In the light of present knowledge, these deductions were largely correct. In fact, many experiments with laboratory animals, also with some of the larger animals, show that a disease manifested by marked osseous changes can be induced by feeding diets low in phosphorus. Phosphorus combined with calcium and magnesium forms about 86.5 per cent of the inorganic materials of the bones, calcium phosphate representing 85 per cent and magnesium phosphate 1.5 per cent. The relation of calcium to phosphoric acid in bone, according to Mathews (11) is 10 Ca : 6 PO_4. This denotes the importance of phosphorus as a mineral constituent of bone.

The results of Moore's (9) experiments add much ground for belief in the inorganic deficiency of the ration as a causative factor in the bone and joint disease described in this paper. The rations Moore fed carried phosphorus at a lower level than do most swine diets. It is regretted that a more detailed description of the pathology of their cases was not included. However, it was clearly recognized that a condition which presented abnormal osseous changes was being dealt with.

Wehrbein (12) in 1916 described a disease of swine characterized by paralysis, which he said was becoming more and more frequent among pigs in Iowa. The fact that the symptoms presented by affected pigs were such as might characterize paresis, caused him to direct his investigations towards the nervous tissue. The work was confined

principally to the examination of the sciatic and axillary nerve trunks. Nerves from the axillary region were examined from cases in which paralysis occurred in the front legs. The lesion observed was characteristic of degeneration, which gave rise to the designation "Polyneuritis parenchymatosa."

We have examined microscopically, sections from the axillary, radial, ulnar, femoral, muscular branches of the sciatic and tibial nerves from five of the pigs used in our experiments and from some field cases, and have found changes identical with those described by Wehrbein. In one of our cases, Pig 9889, Diet 1, Lot XI, with complete cessation of locomotion, it was interesting to note that not all of the fasciculi in a nerve trunk showed evidences of degeneration. A section from the femoral nerve showed a group of fasciculi which appeared normal, then another group in which some degenerated fibers occurred, another group in which more fibers were degenerated, and still others in which nearly all of the fibers were involved. In another case, Pig 9757, Diet 3, Lot IV, a pig which had shown definite symptoms of an osteo-arthropathy, but in which the symptoms had not become severe, a section from the axillary nerve showed some degenerating fibers in all of the fasciculi. The section from the tibial nerve in this case showed many normal fasciculi and some in which the fibers were degenerating. These neurologic changes we believe to be the result of a suspension of functional activity and not a primary lesion. It should also be stated that in the cases just mentioned, there was macroscopic evidence of muscular atrophy, i.e., in the muscles of the limbs.

Wehrbein points out that nothing of importance was revealed by gross examinations of the viscera. The spinal cord, nerves and their coverings did not show gross changes. And further he says "Careful examinations of the bones were made, as we had reason to believe that the disease in question is related to rickets, but without result." The coxo-femoral joint was examined. The teres ligament was swollen at its proximal insertion in some cases. The joint cavity was often filled with blood. Such changes, however, were observed in normal swine which had been handled roughly before killing. He mentions the fact that both rachitis and "paralysis" have been observed in the same animal and that it is often difficult to differentiate between the two macroscopically. The symptoms he describes are very similar to those we have observed and are presented elsewhere in this paper. He reports that the disease usually occurred in pigs less than six months of age and usually from the same litter, tho sows showing definite paralytic symptoms were observed. This occurred after parturition in the sows and was believed to be a disease different from that reported.

Our observations coincide with Wehrbein's in so far as the disease was observed in younger swine more often; that is, in pigs from six to seven months of age or less. We have further observed that the disease existed more often among pigs born in the fall and then pen fed through the winter than in pigs farrowed in the spring or the early summer. Accurate records were not available, so that we could determine the genetic relationship between affected or nonaffected pigs in the droves investigated, but we are of the opinion that familiar heritance does not exist. Familiar susceptibility, on the other hand, may, and possibly does, exist, not by any genetic influences but through environmental trophic conditions. It is not uncommon to find nursing sows exhibiting typical symptoms of an osteo-arthropathy without any of the offspring being affected. In a statement concerning the cause of "polyneuritis parenchymatosa" Wehrbein points out that infections and food intoxications can be safely disregarded but attributes the disease largely to hereditary dispositions and tendencies.

At Cornell University, Maynard, Goldberg, and Miller (13) have been investigating a disease in swine which they designate as "stiffness." Their report covers four trials, in which they used 95 pigs. Thirty-two per cent of the pigs receiving rations particularly low in calcium developed "stiffness." This is 18 per cent less than the number developing a similar condition in the experiments conducted at the Minnesota Station. The ration used at this station, however, was even more restricted in the amount of calcium supplied. Another interesting point of difference between the results obtained at the Minnesota Station and those at Cornell is the fact that none of the pigs receiving rations to which calcium was added at the former institution, developed clinical manifestations, such as showing evidence of stiffness or lameness; while 13 per cent of those receiving rations having an "ample" supply of calcium did show evidence of stiffness in the Cornell trials. In partial explanation (Maynard, et al.) note that the trial was conducted in the winter months when the pigs were stabled. Full benefit of sunshine was not therefore afforded. Also note that a correlation on an ancestral basis existed between the pigs which developed the stiffness and the fact that they were born from sows which varied in bone condition and vigor. These men believe that the trouble (stiffness) is not caused by a mere lack of calcium but that adequate mineral nutrition depends upon assimilation as well. That assimilation is enhanced was brought out by the fact that when some of the pigs which developed stiffness on diets supplying minerals were given 10 cubic centimeters of cod liver oil daily, they soon showed improvement and some returned to normal.

The results obtained by these workers in regard to the production of the disease and with its prevention, agree favorably with the results obtained in these laboratories. That the lesions are principally confined to the long bones, together with lesions at their articulations, is another point of similarity. An extensive study of the microscopic changes in the affected bones was made by them with the result that they too found various pathological manifestations, some which were characteristic of those described for rickets in small animals; others which might be osteoporotic and in some changes somewhat characteristic of scurvy.

CONCLUSIONS

1. There occurs in swine a disease of the bones and joints—an osteo-arthropathy.

2. This disease belongs to the group of trophic diseases. It is a deficiency disease.

3. A lack of calcium is closely associated, or may be the limiting factor, in the rôle as the causative agent. Swine fed rations which supplied calcium at a low level developed typical cases of bone and joint disease.

4. Calcium carbonate (lime, slaked, dried, and then pulverized) when added to the ration at the rate of 2 per cent, apparently supplied the deficiency. None of the pigs receiving it developed the disease.

5. Stiffness, lameness, and later loss of function are characteristic symptoms of the disease. The stiffness and lameness may occur in but one, two, three, or in all four legs.

6. The typical pathologic changes occur principally in the long bones and in the articulations between them. The degree or extent of the morbid change may not be uniform in all the bones of the limbs or in any single bone. This also applies to the articulations. Thus it is imperative that all the diarthrodial joints of the limbs, beginning with the knee and hock and including those proximal to them, should be inspected when examining a patient or cadaver.

7. Because of the irregularity of the histologic changes in the bones we have studied, it was not considered advisable to adopt a specific nomenclature. In some cases the lesion was quite typical of rickets; in others of osteomalacia, and in some of atrophy. There were others that showed changes suggestive of an admixture of rickets, osteomalacia, and atrophy. For these reasons and such as have been mentioned before we are calling attention to a disease of the bones and joints—an osteo-arthropathy—of swine.

ACKNOWLEDGEMENT

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Fig. 1. Pig 9769

This shows a stage of the disease in which there is loss of motor function (akinesia algera). Note how the pig has rooted and torn up the soil, indicating that it is trying to get something from the soil to satisfy a deficiency in its food supply.

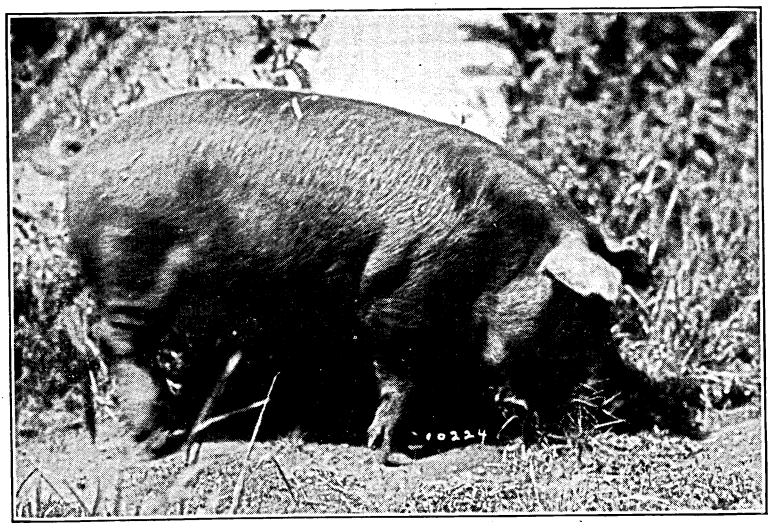

Fig. 2. Pig 9779

This figure shows an early stage of the disease in which the anterior limbs are involved. Note the volar flexion at the right carpus and the slope of the phalanges and also the slight atrophy of the muscles in the region of the arm.

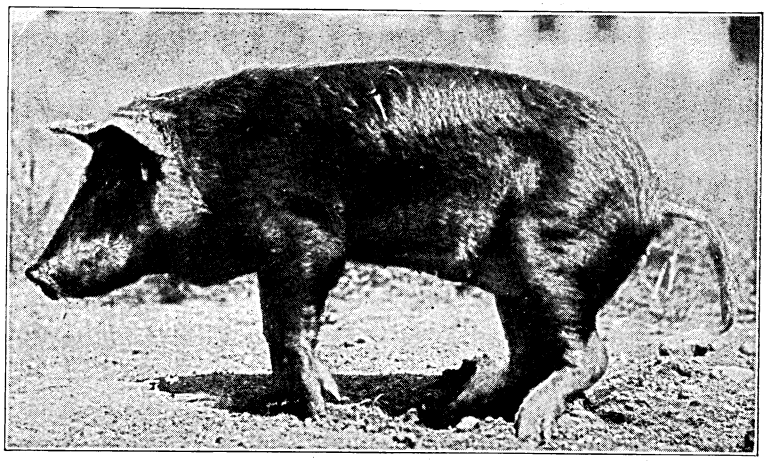

Fig. 3. Pig 9889

This represents a characteristic standing position of many pigs affected with an o teo-arthropathy. The feet are placed farther under the body, the hind parts lowered, and there is marked flexion at the hock joint and the knee joint.

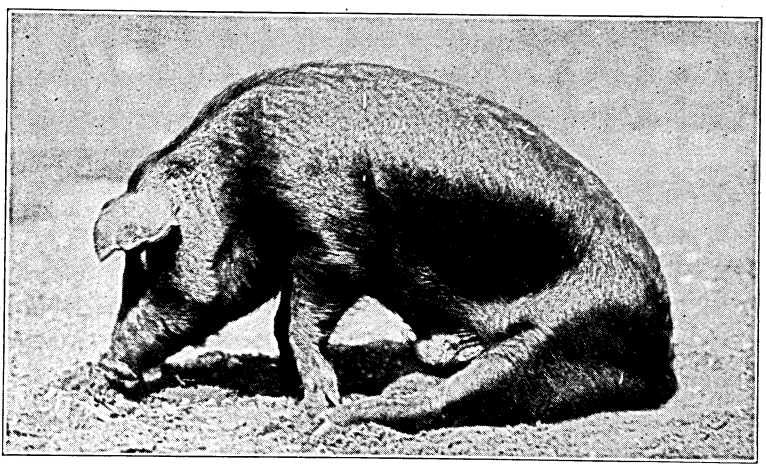

Fig. 4. Pig. 9837

This is typical of a position often assumed by pigs affected with a bone and joint disease. The hind legs are extended forward and outward.

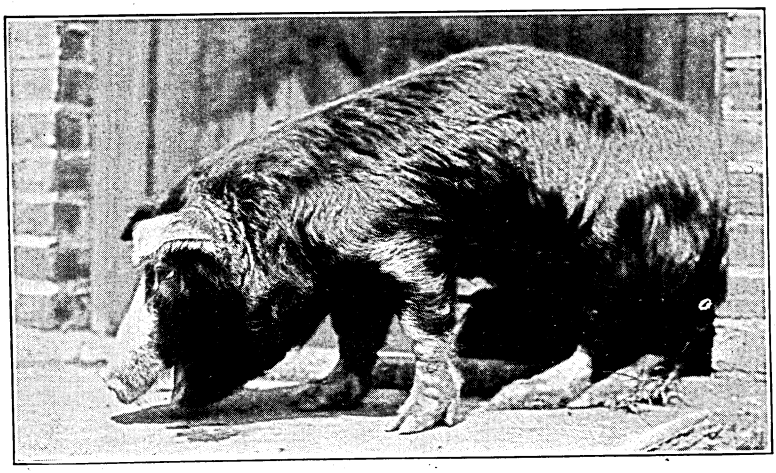

Fig. 5. Representing a Clinical Picture Typical of Rickets

Note the enlargements of the facial bones, the bowing or bent radius, and the position of the hind feet. The spinal column shows marked lordosis. This animal was brought to the laboratory for diagnosis. Compare with Figure 2.

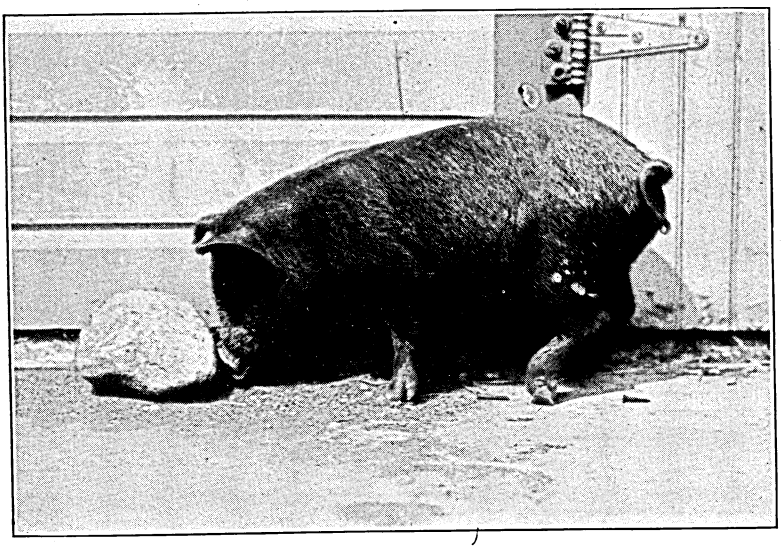

Fig. 6. Small Pig, 25 Pounds in Weight

The pig is nearly four months old and shows typical symptoms of a bone and joint disease.

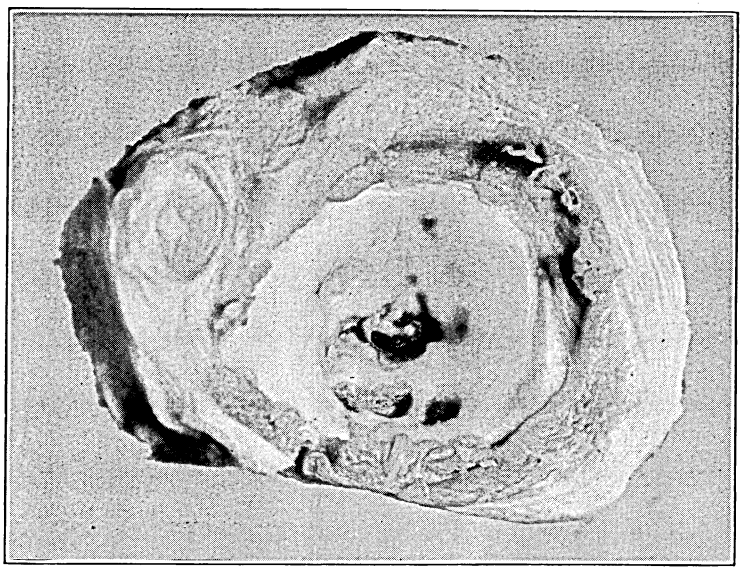

Fig. 7. Articular Surface of the Scapula, Pig 9781

This shows very clearly the extensive erosions, depressions, and pits in the articular cartilage, the thickened synovial layer of the capsule with its swollen villi, and the thick fibrous periarticular tissue.

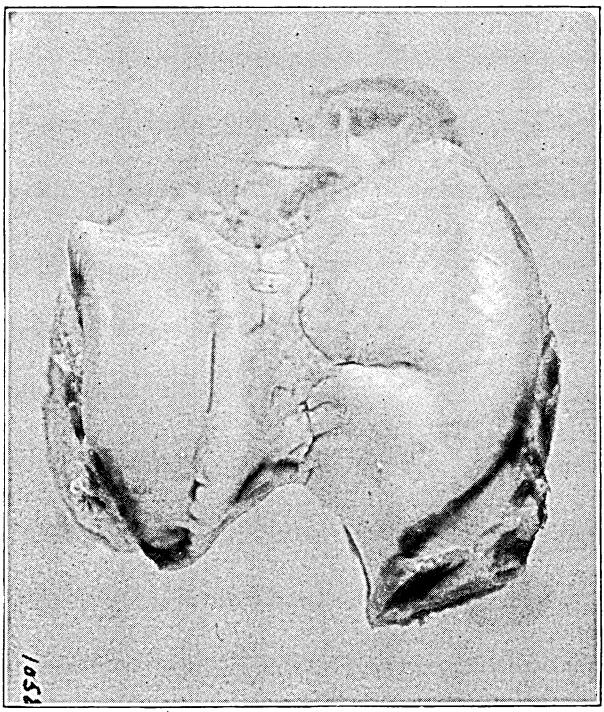

Fig. 8. Distal Extremity of Humerus, Pig 9781

The surface of the cartilage is very uneven and wrinkled, especially in the sagittal groove of the medial condyle. The lateral condyle is normal.

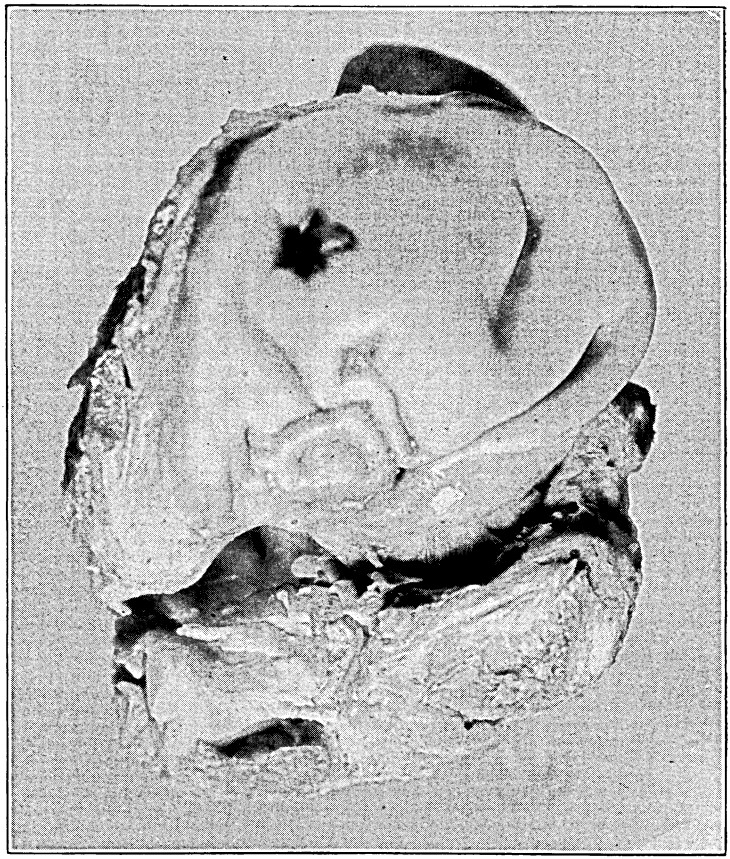

Fig. 9. Proximal Extremity of the Humerus, Pig 9889

Marked wrinkling and crevices in the cartilage are very distinct. The cartilage was very uneven and rough and a deep erosive lesion is apparent.

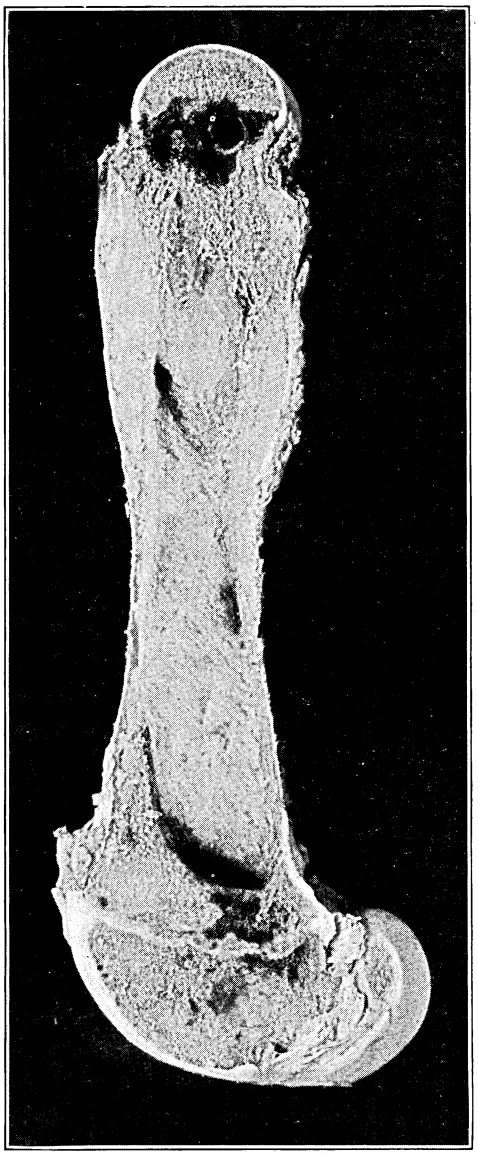

Fig. 10. Longitudinal Section of the Left Femur, Pig 9765

This shows the marked periosteal and subperiosteal thickening at the proximal third of the shaft. This is mostly osteoid tissue. The compact substance of the shaft in this region is very thin. There is an increased amount of fibrous periosteal tissue as shown by the white line. Cavernous hemorrhagic and cryst-like formations can be seen at the proximal metaphysis.

Fig. 11. Section of Shaft of Femur, Pig 9765 (Photomicrograph)

Irregular areas of osteoid and a few bony spicules, between which are a great number of undifferentiated fibroblasts and much fibrin.

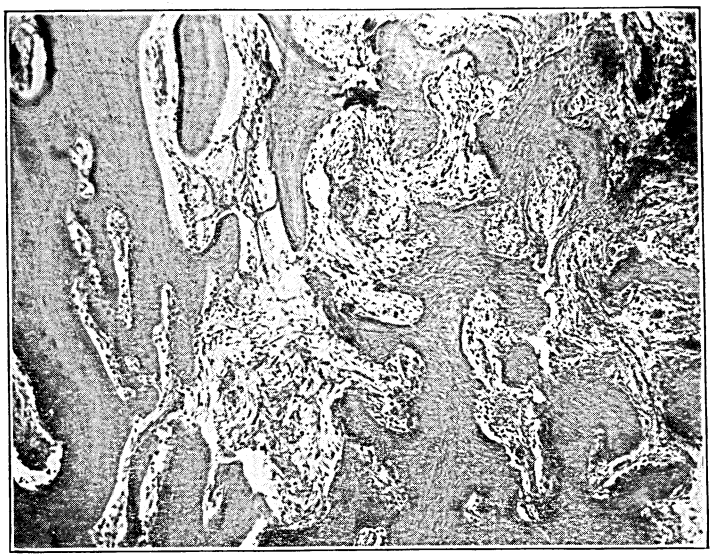

Fig. 12. Section from the Periosteal Thickening, Pig 9765 (Photomicrograph)

This shows the wide osteoid trabeculae in which groups or nests of osteoid cells occur. A few osteoblasts are situated about some of the trabeculae.

Fig. 13. Section from Proximal Metaphysis of Femur, Pig 9769 (Photomicrograph)

This shows a very irregular epiphyseal cartilage. The columns of cartilage cells in some places are also very irregular. A rather wide layer of osteoid is in close proximity.

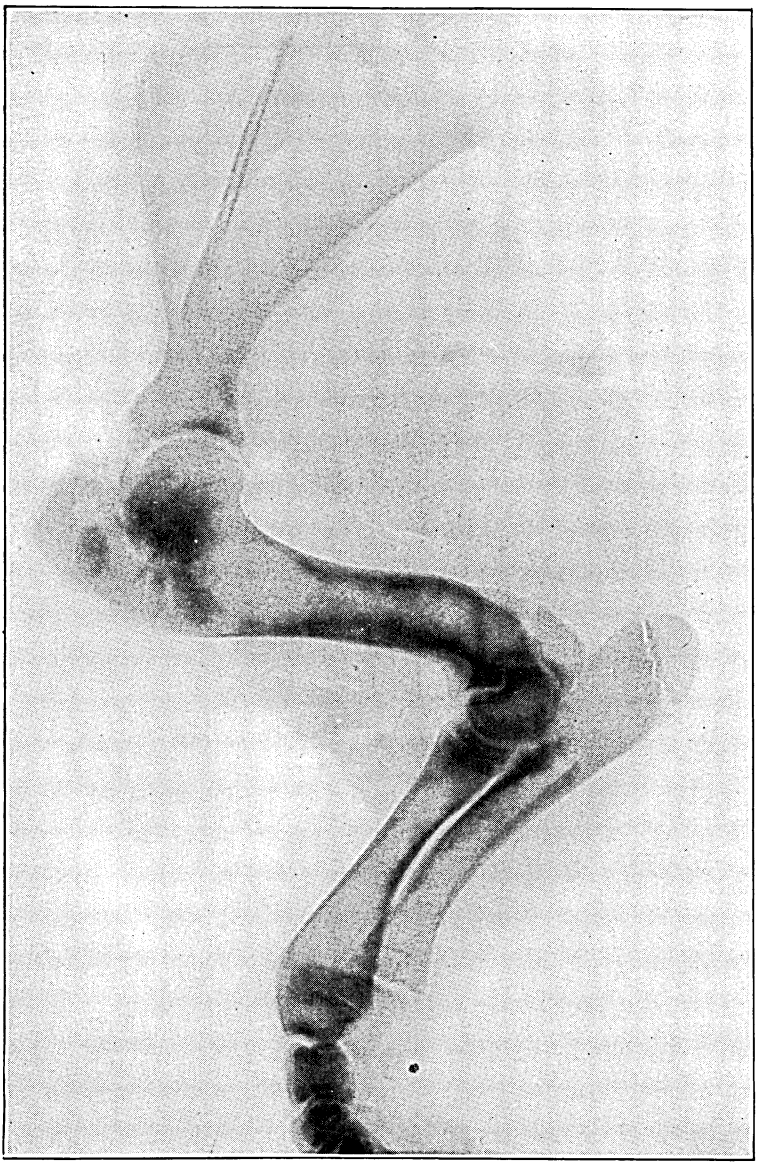

Fig. 14. Left Fore Leg, Pig 9799 (Roentgenograph)

A convex shadow situated about midway of the posterior border of the scapula marks an area of periosteal thickening. The slightly uneven contour of the border of the glenoid cavity indicates a roughened cartilage. There is another area of periosteal thickening on the anterior surface and near the distal extremity of the humerus. The scapula and humerus show evidence of moderate calcium loss, the radius slight loss; the ulna is normal. (The negatives are better adapted for these studies.) See Chart 1.